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Falls Risk Classification Using Smartphone Based Inertial Sensors and Deep Learning

PRESENTED BY

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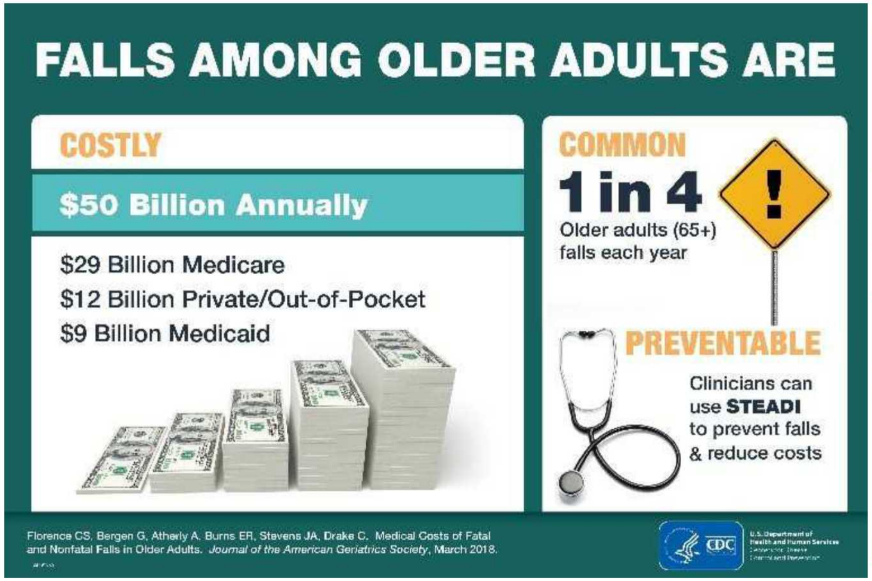
Falling in Older Adults

Definition of a fall
- A fall is an event that causes a person to rest inadvertently on the floor or another lower level

Each year 2.8 million adults are treated for fall related injuries
- Broken bones, hip fractures, traumatic brain injury
- Results in 800,000 hospitalization each year
- Medical costs exceed $50 billion

Emotional Cost of falling
- Increase fear of falling
- Decline in physical activity
- Reduced social interactions
- Depression

Falls Prevention Research
- Research has focused on assessment, prevention, and rehabilitation
- Prior research has focused on factors that attribute to falling
- Qualitative- and mobility-based assessments
- Sensor systems for monitoring gait
- Machine learning for gait analysis



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Sensors for Gait Analysis

Sensor for Gait Analysis
- 3-D motion capture
- Pressure sensitive walkways
- Inertial sensors

Smartphones for gait measurement
- Suite of sensors ideal for monitoring falls risk
- Microelectromechanical Systems (MEMS) inertial measurement units
  - 6- or 9-axis inertial sensors
- Open development environment
- Powerful processing capabilities
  - Mobile Machine Learning and Deep Learning APIs
- Continuous gait monitoring
  - In-home gait monitoring
  - Removes the need for domain experts to analysis test results

MEMS sensors provide a low cost solution for gait monitoring

Deep Learning for Biomedical

Machine Learning and Deep Learning for Biomedical

- Detection of influenza epidemics using search engine data
- Skin cancer classification using deep convolutional neural networks
- Diabetic retinopathy detection using deep convolutional neural networks

Deep Learning for Gait Analysis and Gait Disorder Classification

- Gait parameter estimation (stride length, stride width, swing time, etc) foot mounted inertial sensor data (CNN)
- Gait pattern classification from tomography sensor data (CNN)
- Detection of freezing of gait in Parkinson's patients (CNN)

Deep Learning for Falls Risk Classification

- To our knowledge first to use deep neural networks for falls risk classification from inertial sensor data (6-axis)
- Propose using deep neural networks for learning features related to human motion
- Apply transfer learning to adapt a pre-trained network for falls risk classification

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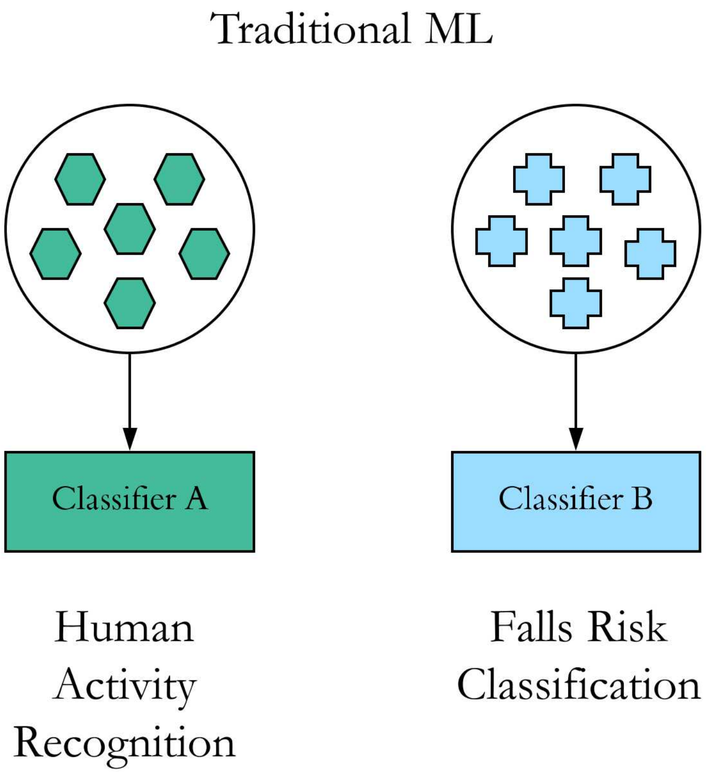
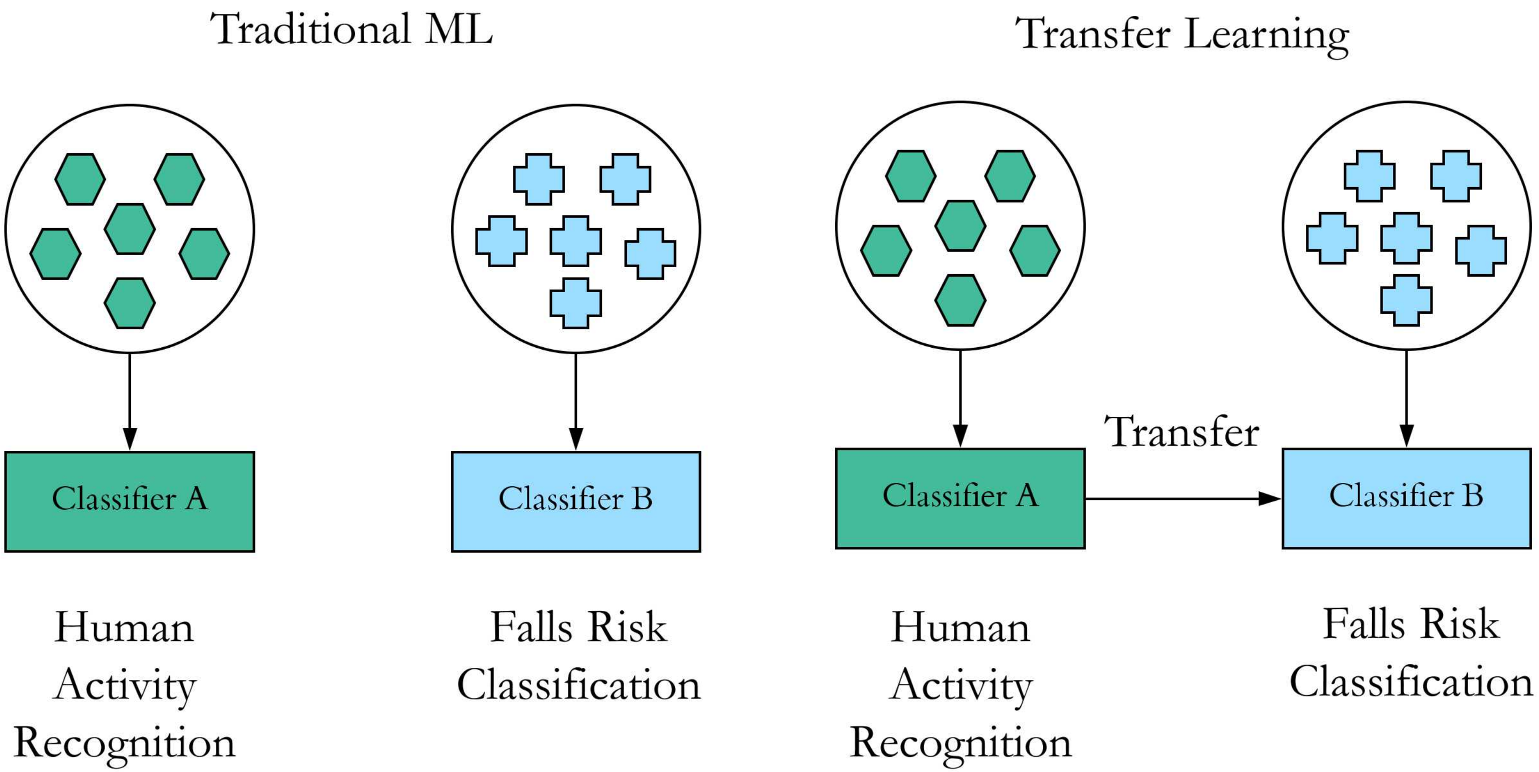
Transfer Learning For Neural Networks



Transfer Learning For Neural Networks



Pedestrian Activity Recognition

Pedestrian Activity Recognition Models
- Trained using publically available large scale human activity recognition dataset
- Human Activity Sensing Corpus (HASC-PAC2016)

Models trained using PyTorch

Trained and evaluated on 2x Nvidia GeForce® Gtx 980 GPUs

Network was trained fully supervised for 250 epochs

Network Parameter Optimization
- Mini-batch gradient descent (batch size of 64 examples)
- minimize cross-entropy loss (measure of difference between probability distributions)
- Adaptive Moment Estimation (Adam) optimizer
- Learning rate of 1e-5
- L^2 regularization with coefficient of 10e-2

Best Pedestrian Activity Recognition Model achieved accuracy of 98.8%

Older Adult Gait Data

electronic caregiver

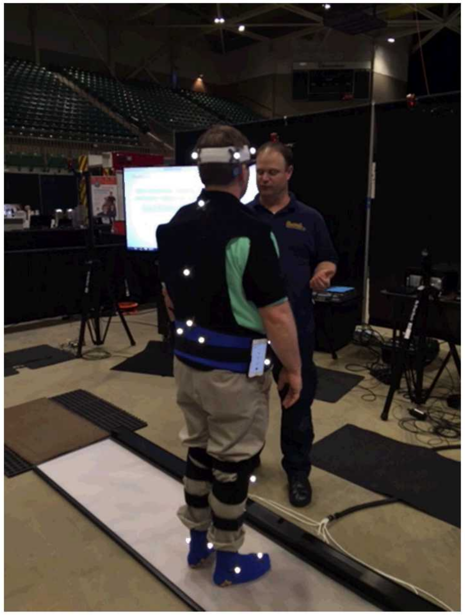
Data collected in partnership with the Electronic Caregiver Company

Sensor System:

- 2x Smartphones with custom apps
- Inertial measurements of gait
- 6 sensor channels, 3-axis accel, 3-axis gyro

Smartphone Data Collection:

- Data collected from 256 participants
- Attached to left and right hip using holster clip and gait belt



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Training and Evaluation

Models trained using PyTorch

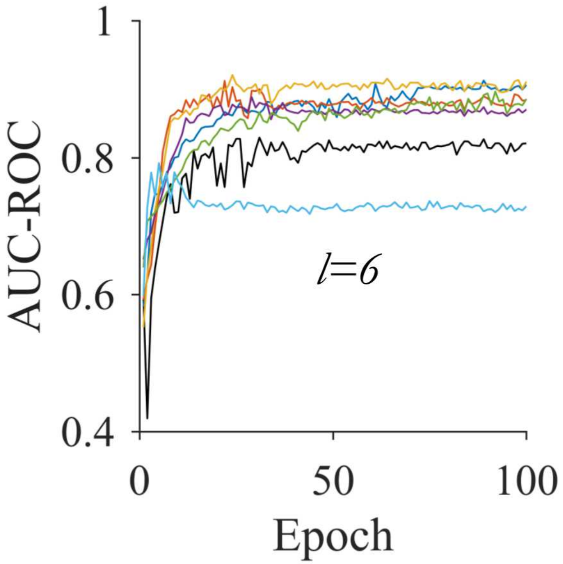
Trained and evaluated on 2x Nvidia GeForce® Gtx 980 GPUs

Each model was trained fully supervised for 250 epochs

Network Parameter Optimization

- Stratified Mini-batch gradient descent (batch size of 64 examples)
- minimize cross-entropy loss (measure of difference between probability distributions)
- Adaptive Moment Estimation (Adam) optimizer
- Learning Rate Scheduler → decreased learning rate by 10^{-3} after 10 epochs of no improvement
- L^2 regularization with coefficient of 10^{-2}
- 80/20 Train/validation split

Network evaluated using Area Under the Receiver Operating Characteristic Curve



Conclusions

Summary of Results

- Show how to pre-train a deep neural network to learn feature representation related to human motion using publicly available pedestrian activity data
- Showed how to use a pre-trained deep neural network as feature extractor for falls risk classification
- Showed how to classify falls risk using inertial gait measurements collected from a smartphone
- End-to-end training of a deep neural network for falls risk classification from inertial measurements of gait